Claims

What is claimed is:

[c1] A projection apparatus for imaging a pattern of a mask onto a substrate by means of a beam of projected charged particles, comprising:

a radiation sensitive layer;

a mask, wherein the mask comprises:

a membrane layer made of a first material,

scattering regions forming the pattern and made of a second material scattering the charged particles more than the membrane layer, and

a plurality of straightly extending supporting struts spaced apart from one another and supporting the membrane layer together with the scattering regions;

a projection apparatus, wherein the projection apparatus comprises:

a beam shaping device for producing the projection beam with a predetermined projection beam cross-section in the mask plane,

a positioning device for moving the projection beam cross-section in the mask plane along a predetermined path over the mask parallel to the direction into which the struts extend; and

a sensor for supplying a measuring signal which is dependent on the number of charged particles impinging on a mark region provided on the mask.

[c2] The projection apparatus according to claim 1, wherein the positioning device is responsive to the measuring signal in order to reduce deviations from the predetermined path.

[c3] The projection apparatus according to claim 1, wherein the projection beam cross-section has a width transverse to the direction into which the struts extend, which corresponds substantially to the inside width between adjacent struts.

[c4] The projection apparatus according to claim 1, wherein the beam shaping device produces at least one auxiliary positioning beam to interact with the mark region provided on the mask, wherein a cross-section of the auxiliary beam is positioned in the mask plane at a predetermined constant distance relative to the projection beam cross-section.

[c5] The projection apparatus according to claim 4, wherein the auxiliary beam cross-section continuously tapers into a direction transverse to a direction into which the path of the beam extends.

[c6] The projection apparatus according to claim 4, wherein the beam shaping means produces two auxiliary positioning beams, whose auxiliary beam cross-sections are spaced apart from one another in the mask plane transverse to the direction into which the struts extend by an inside distance which is larger than the inside width between adjacent struts.

[c7] The projection apparatus according to any one of claims 1 to 6, wherein the positioning device controls the path of the projection beam cross-section such that the number of charged particles impinging on the mark region is minimized.

[c8] The projection apparatus according to any one of claims 1 to 6, wherein the positioning device controls the path of the projection beam cross-section such that

the number of charged particles impinging on the mark regions corresponds to a predetermined value.

[c9] The projection apparatus according to claim 1, wherein the positioning device is responsive to the measuring signal to stop the movement of the projection beam cross-section along the path.

[c10] A mask for a projection apparatus for imaging a pattern of the mask onto a substrate comprising a radiation sensitive layer by means of a beam of projected charged particles, the mask comprising:

a membrane layer made of a first material;

scattering regions forming the pattern and made of a second material scattering the charged particles more than the membrane layer;

a plurality of supporting struts spaced apart from one another and supporting the membrane layer and the scattering regions; and

at least one mark region formed of a mark material, wherein the mark material differs from the first and second materials as regards its interaction with the charged particles, said interaction being detectable by means of a sensor.

[c11] The mask according to claim 10, wherein the mark material exhibits at least one of a different scattering effect, a different reflection effect, and a different absorption effect for the charged particles than the first and second materials.

[c12] The mask according to claim 10, wherein the interaction is detectable by means of at least one of an Auger electron detector, a backscattering electron detector, an X-ray detector, and a fluorescence radiation detector.

[c13] The mask according to claim 10, wherein the mark region is formed by a layer of the third material applied on an end face of the strut facing away from the membrane layer.

[c14] The mask according to claim 10, wherein the mark region is formed by a mark layer of the third material positioned between the membrane layer and the strut.

[c15] The mask according to claim 10, wherein the mark region is formed by a mark layer of the third material positioned on the side of the membrane layer facing away from the strut.

[c16] The mask according to any one of claims 10 to 15, wherein the mark region extends parallel to a strut allocated thereto.

[c17] The mask according to claim 16, wherein the mark region is formed by the strut.

[c18] The mask according to one of claims 10 to 15, wherein the mark region, viewed in projection parallel to the particle beam, coincides with the projected area of the strut.

[c19] The mask according to any one of claims 10 to 15, wherein the mark region, viewed in projection parallel to the particle beam, is positioned within the projected area of the strut and at a predetermined distance from the edges thereof.

[c20] The mask according to any one of claims 10 to 15, wherein the mark region, viewed in projection parallel to the particle beam, is positioned outside of the projected area of the strut.

[c21] The mask according to claim 20, wherein the mark region is positioned at a predetermined distance from the edges of the strut.

[c22] The mask according to one of claims 10 to 15, wherein at least one masking region is provided which, viewed in projection parallel to the particle beam, overlaps with the mark region at least partially and is formed of a material which scatters charged particles to at least one of stronger than the membrane layer, the mark material, and the supporting strut.

[c23] The mask according to claim 22, wherein the material of the masking region comprises the material of the scattering region.

[c24] The mask according to one of claims 10 to 15, wherein the mark material comprises two different mark materials with distinguishable interaction, wherein different mark materials are in each case assigned to adjacent struts.

[c25] A method for exposing a radiation sensitive layer by means of charged particles projected through a mask, the method comprising:

providing a mask;

providing a projection apparatus; and

producing a projection beam and moving the predetermined projection beam cross-section thereof in a plane of the mask parallel to the direction into which the struts extend at least in response to the measuring signal such that the number of charged particles impinging on the mark region is at least one of minimized and corresponds to a predetermined value.

[c26] A method for exposing a radiation sensitive layer by means of charged particles projected through a mask, the method comprising:

providing a mask;

providing a projection apparatus;

producing a projection beam and moving the predetermined projection beam cross-section thereof in a plane of the mask parallel to the direction into which the struts extend; and

stopping the movement in response to the measuring signal.

[c27] The projection apparatus according to claim 2, wherein the projection beam cross-section has a width transverse to the direction into which the struts extend, which corresponds substantially to the inside width between adjacent struts.

[c28] The projection apparatus according to claim 2, wherein the beam shaping device furthermore produces at least one auxiliary positioning beam to interact with the mark region provided on the mask, wherein a cross-section of the auxiliary beam is positioned in the mask plane at a predetermined constant distance relative to the projection beam cross-section.

[c29] The projection apparatus according to claim 3, wherein the beam shaping device furthermore produces at least one auxiliary positioning beam to interact with the mark region provided on the mask, wherein a cross-section of the auxiliary beam is positioned in the mask plane at a predetermined constant distance relative to the projection beam cross-section.

[c30] The projection apparatus according to claim 5, wherein the beam shaping means produces two auxiliary positioning beams, whose auxiliary beam cross-sections are spaced apart from one another in the mask plane transverse to the direction into which the struts extend by an inside distance which is larger than the inside width between adjacent struts.

[c31] The mask according to claim 11, wherein the interaction is detectable by means of at least one of an Auger electron detector, a backscattering electron detector, an X-ray detector, and a fluorescence radiation detector.

[c32] The mask according to claim 11, wherein the mark region is formed by a layer of the third material applied on an end face of the strut facing away from the membrane layer.

[c33] The mask according to claim 12, wherein the mark region is formed by a layer of the third material applied on an end face of the strut facing away from the membrane layer.

[c34] The mask according to claim 11, wherein the mark region is formed by a mark layer of the third material positioned between the membrane layer and the strut.

[c35] The mask according to claim 12, wherein the mark region is formed by a mark layer of the third material positioned between the membrane layer and the strut.

[c36] The mask according to claim 11, wherein the mark region is formed by a mark layer of the third material positioned on the side of the membrane layer facing away from the strut.

[c37] The mask according to claim 12, wherein the mark region is formed by a mark layer of the third material positioned on the side of the membrane layer facing away from the strut.